

# SCIENCE STANDARDS ARTICULATED BY GRADE LEVEL

## Grade 4

The goal in the development of the standard was to assure that the six strands and five unifying concepts are interwoven into a fabric of science that represents the true nature of science. Students have the opportunity to develop both the skills and content knowledge necessary to be scientifically literate members of the community.

Strands 1, 2, and 3 are designed to be explicitly taught *and* embedded *within* each of the content Strands 4, 5, and 6, and are not intended to be taught in isolation. The processes, skills, and content of the first three strands are designed to “umbrella” and complement the content of Life Science, Physical Science, and Earth and Space Science.

### Strand 1: Inquiry Process

Inquiry Process establishes the basis for students’ learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.

#### Concept 1: Observations, Questions, and Hypotheses

Observe, ask questions, and make predictions.

PO 1. Differentiate inferences from observations.

PO 2. Formulate a relevant question through observations that can be tested by an investigation.  
(See M04-S2C1-01)

PO 3. Formulate predictions in the realm of science based on observed cause and effect relationships.

PO 4. Locate information (e.g., book, article, website) related to an investigation.  
(See W04-S3C6-01 and R04-S3C1-05)

#### Concept 2: Scientific Testing (Investigating and Modeling)

Participate in planning and conducting investigations, and recording data.

*PO 1. Demonstrate safe behavior and appropriate procedures (e.g., use and care of technology, materials, organisms) in all science inquiry.*

- Alternate:**
1. Demonstrate safe behavior and appropriate procedures to set up an experiment by sequentially following three-step directions.
  2. Demonstrate safe behavior and appropriate procedures by sequentially following two step directions with picture cues.
  3. Demonstrate safe behavior by following a one-step direction using objects/partial objects, tactile symbols, or pictures.

PO 2. Plan a simple investigation that identifies the variables to be controlled.

- Alternate:**
1. Given a simple investigation, choose one variable to measure.
  2. Through guided class discussion, identify a variable for a simple investigation.
  3. Using objects/partial objects, tactile symbols, or pictures, identify two vocabulary words associated with a guided investigation.

*Italics denote a repetition of a performance objective (learned in an earlier grade) that is to be applied to grade level content or at a higher level of complexity.*

## Concept 2: Scientific Testing (Investigating and Modeling)

Participate in planning and conducting investigations, and recording data.

PO 3. Conduct controlled investigations (e.g., related to erosion, plant life cycles, weather, magnetism) in life, physical, and Earth and space sciences.

- Alternate:**
1. Use simple tools, such as rulers, thermometers, magnifiers, and balances, to collect data.
  2. Match customary units of measurement (e.g., weight, length, temperature, volume) to appropriate tools.
  3. Identify (using receptive or expressive language) a simple measurement tool associated with a guided investigation.

PO 4. Measure using appropriate tools (e.g., ruler, scale, balance) and units of measure (i.e., metric, U.S. customary).

- Alternate:**
1. Given a simple investigation, use measurement tools to perform multiple steps of an investigation.
  2. Given a simple investigation, observe and collect data.
  3. Use a simple measurement tool associated with a guided investigation.

*PO 5. Record data in an organized and appropriate format (e.g., t-chart, table, list, written log).*

- Alternate:**
1. *Record data on a single-bar graph or line graph using organized data.*
  2. *With appropriate labels, titles, and organized data provided, record data on a single-bar graph or line graph.*
  3. *Given a model, record data on a simple pictograph or tally chart from organized data.*

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### Concept 3: Analysis and Conclusions

Organize and analyze data; compare to predictions.

PO 1. Analyze data obtained in a scientific investigation to identify trends.

- Alternate:**
1. Identify trends (changes) in data obtained in an investigation.
  2. Organize data on a graph or table template.
  3. Organize objects, events, organisms, according to various characteristics.

PO 2. Formulate conclusions based upon identified trends in data.

- Alternate:**
1. Given appropriate graphic representation of organized data, formulate a conclusion based on identified trends in data.
  2. When given two possible choices, select a reasonable conclusion based on identified trends in data.
  3. Participate in the collection of data to solve a problem or answer a question using graphs, charts, and tables

PO 3. Determine that data collected is consistent with the formulated question.

PO 4. Determine whether the data supports the prediction for an investigation.

- Alternate:**
1. Record observations from a scientific inquiry using tools such as objects, pictures, checklists, or a computer log.
  2. Using a template, record observations from a scientific inquiry using tools such as objects, pictures, checklists, or a computer log.
  3. Make a simple pictograph or tally chart of organized data from grade-level scientific inquiry.

PO 5. Develop new questions and predictions based upon the data collected in the investigation.

### Concept 4: Communication

Communicate results of investigations.

PO 1. Communicate verbally or in writing the results of an inquiry.

- Alternate:**
1. Communicate results of investigations verbally or in writing.
  2. Communicate results of investigations using pictures, graphs, models, and/or words.
  3. Communicate observations with objects/partial objects, tactile objects, pictures, models, and/or words.

PO 2. Choose an appropriate graphic representation for collected data:

- bar graph
- line graph
- Venn diagram
- model

PO 3. Communicate with other groups or individuals to compare the results of a common investigation.

- Alternate:**
1. Use an appropriate graphic representation of the data to communicate results of an investigation.
  2. Communicate the results of an investigation using pictures, models, and/or words.
  3. Communicate the results of an investigation using objects/partial objects or tactile objects.

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## Strand 2: History and Nature of Science

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.

### Concept 1: History of Science as a Human Endeavor

Identify individual and cultural contributions to scientific knowledge.

*PO 1. Identify how diverse people and/or cultures, past and present, have made important contributions to scientific innovations (e.g., Margaret Mead [anthropologist], supports Strand 4; Nikola Tesla [engineer, inventor] supports Strand 5; Michael Faraday [scientist], supports Strand 5; Benjamin Franklin [scientist], supports Strand 5).*

*PO 2. Describe science-related career opportunities.*

- Alternate:**
- 1. Compare two science-related career opportunities.*
  - 2. Explore two science-related career opportunities.*
  - 3. Identify the healthcare workers (e.g. physical therapists, occupational therapists, and speech therapists) who work with me, their roles, and the tools they use to help me to be more independent.*

### Concept 2: Nature of Scientific Knowledge

Understand how science is a process for generating knowledge.

*PO 1. Explain the role of experimentation in scientific inquiry.*

*PO 2. Describe the interaction of components in a system (e.g., flashlight, radio).*

*PO 3. Explain various ways scientists generate ideas (e.g., observation, experiment, collaboration, theoretical and mathematical models).*

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### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.

#### Concept 1: Changes in Environments

Describe the interactions between human populations, natural hazards, and the environment.

- PO 1. Describe how natural events and human activities have positive and negative impacts on environments (e.g., fire, floods, pollution, dams).
- PO 2. Evaluate the consequences of environmental occurrences that happen either rapidly (e.g., fire, flood, tornado) or over a long period of time (e.g., drought, melting ice caps, the greenhouse effect, erosion).

#### Concept 2: Science and Technology in Society

Understand the impact of technology.

- PO 1. Describe how science and technology (e.g., computers, air conditioning, medicine) have improved the lives of many people.  
**Alternate:**
1. Given two scientific inventions (e.g., computers, air conditioning, medicines) describe how they have improved lives.
  2. Given a simple problem, find a solution.
  3. Identify simple tools and their uses that make tasks easier or more accessible
- PO 2. Describe benefits (e.g., easy communications, rapid transportation) and risks (e.g., pollution, destruction of natural resources) related to the use of technology.
- PO 3. Design and construct a technological solution to a common problem or need using common materials.*

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## Strand 4: Life Science

Life Science expands students' biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

### Concept 1: Characteristics of Organisms

Understand that basic structures in plants and animals serve a function.

PO 1. Compare structures in plants (e.g., roots, stems, leaves, flowers) and animals (e.g., muscles, bones, nerves) that serve different functions in growth and survival.

- Alternate:**
1. Identify five parts of plants and their functions or five parts of animals and their functions.
  2. Identify three parts of plants and their functions or three parts of animals and their functions.
  3. Distinguish between pictures/objects of living and nonliving things.

PO 2. Classify animals by identifiable group characteristics:

- vertebrates – mammals, birds, fish, reptiles, amphibians
- invertebrates – insects, arachnids

- Alternate:**
1. Classify animals by two group characteristics (e.g., scales, feathers, fur; number of legs; size; camouflage colors; walk, fly, swim).
  2. Sort pictures/objects of animals into groups of same or different characteristics.
  3. Match pictures/objects of like animals.

### Concept 2: Life Cycles

Understand the life cycles of plants and animals.

No performance objectives at this grade level

### Concept 3: Organisms and Environments

Understand the relationships among various organisms and their environment.

PO 1. Describe ways various resources (e.g., air, water, plants, animals, soil) are utilized to meet the needs of a population.

- Alternate:**
1. Describe various resources (e.g. air, water, soil) that are utilized to meet the needs of a population.
  2. Recognize that plants and animals have basic needs (e.g. food, water, air, shelter, and light) to survive.
  3. Identify the plants and animals that exist in the local environment.

PO 2. Differentiate renewable resources from nonrenewable resources.

PO 3. Analyze the effect that limited resources (e.g., natural gas, minerals) may have on an environment.

- Alternate:**
1. Describe the effect that limited resources may have on an environment.
  2. Describe how plants and animals within a habitat are dependent on each other.
  3. Describe various plant and animal habitats.

PO 4. Describe ways in which resources can be conserved (e.g., by reducing, reusing, recycling, finding substitutes).

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#### **Concept 4: Diversity, Adaptation, and Behavior**

Identify plant and animal adaptations.

PO 1. Recognize that successful characteristics of populations are inherited traits that are favorable in a particular environment.

PO 2. Give examples of adaptations that allow plants and animals to survive.

- camouflage – horned lizards, coyotes
- mimicry – Monarch and Viceroy butterflies
- physical – cactus spines
- mutualism – species of acacia that harbor ants, which repel other harmful insects

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## Strand 5: Physical Science

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

### Concept 1: Properties of Objects and Materials

Classify objects and materials by their observable properties.

No performance objectives at this grade level

### Concept 2: Position and Motion of Objects

Understand spatial relationships and the way objects move.

No performance objectives at this grade level

### Concept 3: Energy and Magnetism

Investigate different forms of energy.

PO 1. Demonstrate that electricity flowing in circuits can produce light, heat, sound, and magnetic effects.

PO 2. Construct series and parallel electric circuits.

PO 3. Explain the purpose of conductors and insulators in various practical applications.

PO 4. Investigate the characteristics of magnets (e.g., opposite poles attract, like poles repel, the force between two magnet poles depends on the distance between them).

PO 5. State cause and effect relationships between magnets and circuitry.

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## Strand 6: Earth and Space Science

Earth and Space Science provides the foundation for students to develop an understanding of the Earth, its history, composition, and formative processes, and an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic laws, theories, and models that explain the world (NSES, 1995). By studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.

### Concept 1: Properties of Earth Materials

Identify the basic properties of Earth materials.

No performance objectives at this grade level

### Concept 2: Earth's Processes and Systems

Understand the processes acting on the Earth and their interaction with the Earth systems.

PO 1. Identify the Earth processes that cause erosion.

PO 2. Describe how currents and wind cause erosion and land changes.

PO 3. Describe the role that water plays in the following processes that alter the Earth's surface features:

- erosion
- deposition
- weathering

PO 4. Compare rapid and slow processes that change the Earth's surface, including:

- rapid – earthquakes, volcanoes, floods
- slow – wind, weathering

PO 5. Identify the Earth events that cause changes in atmospheric conditions (e.g., volcanic eruptions, forest fires).

PO 6. Analyze evidence that indicates life and environmental conditions have changed (e.g., tree rings, fish fossils in desert regions, ice cores).

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### Concept 3: Changes in the Earth and Sky

Understand characteristics of weather conditions and climate.

PO 1. Identify the sources of water within an environment (e.g., ground water, surface water, atmospheric water, glaciers).

- Alternate:**
1. Identify the sources of water in different climates.
  2. Identify the sources of water in local climate.
  3. Identify a source of water in local climate.

PO 2. Describe the distribution of water on the Earth's surface.

- Alternate:**
1. Name three bodies of water found on a map or globe.
  2. Indicate three bodies of water found on a map or globe.
  3. Identify a body of water in local area.

PO 3. Differentiate between weather and climate as they relate to the southwestern United States.

- Alternate:**
1. Describe the weather that occurs in different climates in the southwestern United States.
  2. Describe the different bodies of water in regional or local area.
  3. Identify a current weather condition (e.g., sunny, hot, rainy, windy).

PO 4. Measure changes in weather (e.g., precipitation, wind speed, barometric pressure).

- Alternate:**
1. Using recorded temperatures readings, compare temperature changes between months.
  2. Using a thermometer, record the temperature readings over a five-day period.
  3. Using a thermometer, indicate the days' temperature reading.

PO 5. Interpret the symbols on a weather map or chart to identify the following:

- temperatures
- fronts
- precipitation

- Alternate:**
1. Interpret two of the following symbols on a weather map or chart:
    - temperatures
    - fronts
    - precipitation
  2. Identify a weather symbol on a weather map or chart.
  3. Match a weather symbol to daily weather.

PO 6. Compare weather conditions in various locations (e.g., regions of Arizona, various U.S. cities, coastal vs. interior geographical regions).

- Alternate:**
1. Describe weather conditions in various locations.
  2. Explain how the weather affects daily activities.
  3. Give an example of how the current weather affects the outdoor activity.

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# SCIENCE STANDARDS ARTICULATED BY GRADE LEVEL

## Grade 8

The goal in the development of the standard was to assure that the six strands and five unifying concepts are interwoven into a fabric of science that represents the true nature of science. Students have the opportunity to develop both the skills and content knowledge necessary to be scientifically literate members of the community.

Strands 1, 2, and 3 are designed to be explicitly taught *and* embedded *within* each of the content Strands 4, 5, and 6, and are not intended to be taught in isolation. The processes, skills, and content of the first three strands are designed to “umbrella” and complement the content of Life Science, Physical Science, and Earth and Space Science.

### Strand 1: Inquiry Process

Inquiry Process establishes the basis for students’ learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.

#### Concept 1: Observations, Questions, and Hypotheses

Formulate predictions, questions, or hypotheses based on observations. Locate appropriate resources.

*PO 1. Formulate questions based on observations that lead to the development of a hypothesis.  
(See M08-S2C1-01)*

PO 2. Use appropriate research information, not limited to a single source, to use in the development of a testable hypothesis.  
(See W08-S3C6-01, R08-S3C1-06, and R08-S3C2-03)

PO 3. Generate a hypothesis that can be tested.

#### Concept 2: Scientific Testing (Investigating and Modeling)

Design and conduct controlled investigations.

*PO 1. Demonstrate safe behavior and appropriate procedures (e.g., use and care of technology, materials, organisms) in all science inquiry.*

**Alternate:**

1. Demonstrate safe behavior and appropriate procedures by using a comprehensive checklist delineating safe procedures, materials, and equipment for a science inquiry.
2. Demonstrate safe behavior and appropriate procedures by determining whether a specific three-step task is completed by using a checklist to ensure all of the steps were followed in the right order, with picture cues to assist.
3. Demonstrate safe behavior by indicating that an activity has been completed by putting the related object/partial object, tactile symbol, or picture in a location symbolizing “finished.”

PO 2. Design a controlled investigation to support or reject a hypothesis.

**Alternate:**

1. Given a grade-level investigation, choose one variable to measure.
2. Through guided class discussion, name variables for a grade-level investigation.
3. Using objects/partial objects, tactile symbols, or pictures, name two vocabulary words associated with a guided grade-level investigation.

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## Concept 2: Scientific Testing (Investigating and Modeling)

Design and conduct controlled investigations.

PO 3. Conduct a controlled investigation to support or reject a hypothesis.

PO 4. *Perform measurements using appropriate scientific tools (e.g., balances, microscopes, probes, micrometers).*

- Alternate:**
1. *Use scientific tools, such as balances, microscopes, and scales, to collect data.*
  2. *Match customary units of measurement (e.g., weight, length, temperature, volume) to scientific tools.*
  3. *Name (using receptive or expressive language) scientific measurement tools associated with a guided grade-level investigation.*

PO 5. *Keep a record of observations, notes, sketches, questions, and ideas using tools such as written and/or computer logs.*

- Alternate:**
1. *Record observations from a scientific inquiry using tools such as objects, pictures, checklists, or a computer log.*
  2. *Using a template, record observations from a scientific inquiry using tools such as objects, pictures, checklists, or a computer log.*
  3. *Make a simple pictograph or tally chart of organized data from grade-level scientific inquiry.*

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### Concept 3: Analysis and Conclusions

Analyze and interpret data to explain correlations and results; formulate new questions.

*PO 1. Analyze data obtained in a scientific investigation to identify trends.*

*(See M08-S2C1-08)*

*PO 2. Form a logical argument about a correlation between variables or sequence of events (e.g., construct a cause-and-effect chain that explains a sequence of events).*

PO 3. Interpret data that show a variety of possible relationships between two variables, including:

- positive relationship
- negative relationship
- no relationship

**Alternate:**

1. Explain the relationship between two variables.
2. Given a table or graph, explain the data.
3. Identify the variables in an investigation.

PO 4. Formulate a future investigation based on the data collected.

PO 5. Explain how evidence supports the validity and reliability of a conclusion.

PO 6. Identify the potential investigational error that may occur (e.g., flawed investigational design, inaccurate measurement, computational errors, unethical reporting).

PO 7. Critique scientific reports from periodicals, television, or other media.

*PO 8. Formulate new questions based on the results of a previous investigation.*

### Concept 4: Communication

Communicate results of investigations.

PO 1. Communicate the results of an investigation.

**Alternate:**

1. Communicate results of investigations verbally or in writing.
2. Communicate results of investigations using pictures, graphs, models, and/or words.
3. Communicate observations with objects/partial objects, tactile objects, pictures, models, and/or words

*PO 2. Choose an appropriate graphic representation for collected data:*

- *line graph*
- *double bar graph*
- *stem and leaf plot*
- *histogram*

**Alternate:**

1. *Use an appropriate graphic representation of the data to communicate results of an investigation.*
2. *Describe the results of an investigation using pictures, models, and/or words.*
3. *Communicate the results of an investigation using objects/partial objects, tactile symbols.*

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### Concept 4: Communication

Communicate results of investigations.

PO 3. Present analyses and conclusions in clear, concise formats.  
(See W08-S3C6-02)

PO 4. Write clear, step-by-step instructions for conducting investigations or operating equipment (without the use of personal pronouns).

- Alternate:**
1. Write three step instructions for conducting investigations or operating equipment.
  2. Using words or pictures, sequence three-step instructions for conducting investigations or operating equipment.
  3. In an investigation, choose one step from a field of three illustrations or objects (two of which are unrelated to the investigation)

PO 5. *Communicate the results and conclusion of the investigation.*

- Alternate:**
1. *Communicate one result of an investigation verbally and/or in writing.*
  2. *Communicate the result of one step in an investigation, using pictures or models.*
  3. *Choose the illustration or object that shows the results of an investigation.*

## Strand 2: History and Nature of Science

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.

### Concept 1: History of Science as a Human Endeavor

Identify individual, cultural, and technological contributions to scientific knowledge.

PO 1. *Identify how diverse people and/or cultures, past and present, have made important contributions to scientific innovations (e.g., Watson and Crick [scientists], support Strand 4; Rosalind Franklin [scientist], supports Strand 4; Charles Darwin [scientist], supports Strand 4; George Washington Carver [scientist, inventor], supports Strand 4; Joseph Priestley [scientist], supports Strand 5; Sir Frances Bacon [philosopher], supports Strand 5; Isaac Newton [scientist], supports Strand 5).*

PO 2. Evaluate the effects of the following major scientific milestones on society:

- Mendelian Genetics
- Newton's Laws

PO 3. Evaluate the impact of a major scientific development occurring within the past decade.

PO 4. Evaluate career opportunities related to life and physical sciences.

- Alternate:**
1. Compare employment requirements related to two life and physical sciences.
  2. Explore skills and requirements that relate to two science careers.
  3. Identify personal interests that relate to science (interest inventory).

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## Concept 2: Nature of Scientific Knowledge

Understand how science is a process for generating knowledge.

*PO 1. Apply the following scientific processes to other problem solving or decision making situations:*

observing	predicting
questioning	organizing data
communicating	inferring
comparing	generating hypotheses
measuring	identifying variables
classifying	

*PO 2. Describe how scientific knowledge is subject to change as new information and/or technology challenges prevailing theories.*

PO 3. Defend the principle that accurate record keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society.

PO 4. Explain why scientific claims may be questionable if based on very small samples of data, biased samples, or samples for which there was no control.

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### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.

#### Concept 1: Changes in Environments

Describe the interactions between human populations, natural hazards, and the environment.

PO 1. Analyze the risk factors associated with natural, human induced, and/or biological hazards, including:

- waste disposal of industrial chemicals
- greenhouse gases

PO 2. Analyze possible solutions to address the environmental risks associated with chemicals and biological systems.

#### Concept 2: Science and Technology in Society

Develop viable solutions to a need or problem.

*PO 1. Propose viable methods of responding to an identified need or problem.*

*PO 2. Compare solutions to best address an identified need or problem.*

- Alternate:**
1. Compare solutions based on cost, benefits, and risks as it relates to a home safety and maintenance problem.
  2. Identify solutions to best address a home safety and maintenance problem.
  3. Indicate a solution to one of the following problems:
    - Clogged drain
    - Household pests
    - Conservation issues (water leaks, energy consumption, fans, light bulbs, air conditioner)

*PO 3. Design and construct a solution to an identified need or problem using simple classroom materials.*

PO 4. Compare risks and benefits of the following technological advances:

- radiation treatments
- genetic engineering (See Strand 4 Concept 2)
- airbags (See Strand 5 Concept 2)

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## Strand 4: Life Science

Life Science expands students' biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

### Concept 1: Structure and Function in Living Systems

Understand the relationships between structures and functions of organisms.

No performance objectives at this grade level

### Concept 2: Reproduction and Heredity

Understand the basic principles of heredity.

PO 1. Explain the purposes of cell division:

- growth and repair
- reproduction

PO 2. Explain the basic principles of heredity using the human examples of:

- eye color
- widow's peak
- blood type

**Alternate:**

1. Compare personal traits with family traits.
2. Choose two personal traits and identify which family member has that same trait.
3. Identify personal traits.

PO 3. Distinguish between the nature of dominant and recessive traits in humans.

### Concept 3: Populations of Organisms in an Ecosystem

Analyze the relationships among various organisms and their environment.

No performance objectives at this grade level

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#### **Concept 4: Diversity, Adaptation, and Behavior**

Identify structural and behavioral adaptations.

PO 1. Explain how an organism's behavior allows it to survive in an environment.

PO 2. Describe how an organism can maintain a stable internal environment while living in a constantly changing external environment.

PO 3. Determine characteristics of organisms that could change over several generations.

PO 4. Compare the symbiotic and competitive relationships in organisms within an ecosystem (e.g., lichen, mistletoe/tree, clownfish/sea anemone, native/non-native species).

PO 5. Analyze the following behavioral cycles of organisms:

- hibernation
- migration
- dormancy (plants)

PO 6. Describe the following factors that allow for the survival of living organisms:

- protective coloration
- beak design
- seed dispersal
- pollination

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## Strand 5: Physical Science

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

### Concept 1: Properties and Changes of Properties in Matter

Understand physical and chemical properties of matter.

PO 1. Identify different kinds of matter based on the following physical properties:

- states
- density
- boiling point
- melting point
- solubility

PO 2. Identify different kinds of matter based on the following chemical properties:

- reactivity
- pH
- oxidation (corrosion)

PO 3. Identify the following types of evidence that a chemical reaction has occurred:

- formation of a precipitate
- generation of gas
- color change
- absorption or release of heat

PO 4. Classify matter in terms of elements, compounds, or mixtures.

PO 5. Classify mixtures as being homogeneous or heterogeneous.

PO 6. Explain the systematic organization of the periodic table.

PO 7. Investigate how the transfer of energy can affect the physical and chemical properties of matter.

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### **Concept 2: Motion and Forces**

Understand the relationship between force and motion.

PO 1. Demonstrate velocity as the rate of change of position over time.

PO 2. Identify the conditions under which an object will continue in its state of motion (Newton's 1<sup>st</sup> Law of Motion).

PO 3. Describe how the acceleration of a body is dependent on its mass and the net applied force (Newton's 2<sup>nd</sup> Law of Motion).

PO 4. Describe forces as interactions between bodies (Newton's 3<sup>rd</sup> Law of Motion).

PO 5. Create a graph devised from measurements of moving objects and their interactions, including:

- position-time graphs
- velocity-time graphs

### **Concept 3: Transfer of Energy**

Understand that energy can be stored and transferred.

No performance objectives at this grade level

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## Strand 6: Earth and Space Science

Earth and Space Science provides the foundation for students to develop an understanding of the Earth, its history, composition, and formative processes, and an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic laws, theories, and models that explain the world (NSES, 1995). By studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.

### Concept 1: Structure of the Earth

Describe the composition and interactions between the structure of the Earth and its atmosphere.

No performance objectives at this grade level

### Concept 2: Earth's Processes and Systems

Understand the processes acting on the Earth and their interaction with the Earth systems.

No performance objectives at this grade level

### Concept 3: Earth in the Solar System

Understand the relationships of the Earth and other objects in the solar system.

No performance objectives at this grade level

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# SCIENCE STANDARDS ARTICULATED BY GRADE LEVEL

## Grade 10

The Arizona high school science standard was designed to support the instruction and assessment of students. Science instruction should involve students actively using scientific processes to understand course content and make connections to real life and related areas of study. The goal in the development of the standard was to assure that the six strands and five unifying concepts are interwoven into a fabric of science that represents the true nature of science. Students have the opportunity to develop both the skills and content knowledge necessary to be scientifically literate members of the community.

Strands 1, 2, and 3 (Inquiry Process, History and Nature of Science, and Science in Personal and Social Perspective) contain the processes and connections desired of Arizona students and must, therefore, be reflected in all science courses. These strands are designed to be explicitly taught *and embedded within* each of the content Strands 4, 5, and 6, and are not intended to be taught in isolation. The processes, skills, and content of the first three strands are designed to “umbrella” and complement the content of Life Science, Physical Science, and Earth and Space Science.

At the high school level, Strands 4, 5, and 6 (Life Science, Physical Science, and Earth and Space Science) contain content area knowledge and skills that are, by nature, course specific. These strands were written to provide frameworks for complete courses in Life, Physics, Chemistry, and Earth and Space sciences.

The high school science Arizona Instrument to Measure Standards (AIMS) will be administered as an end of course test. For each course tested, all performance objectives in Strands 1, 2 and 3 may be included on the assessment. Depending on the course tested, performance objectives from Strand 4, 5, or 6, will be measured. For example, an end of course AIMS for high school biology could include performance objectives from Strands 1, 2, 3, and 4. A blueprint of the Science AIMS will be available following test development.

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## Strand 1: Inquiry Process

Inquiry Process establishes the basis for students' learning in science. Students use scientific processes: questioning, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating results.

### Concept 1: Observations, Questions, and Hypotheses

Formulate predictions, questions, or hypotheses based on observations. Evaluate appropriate resources.

- PO 1. Evaluate scientific information for relevance to a given problem. (See R09-S3C1, R10-S3C1, R11-S3C1, and R12-S3C1)
- PO 2. Develop questions from observations that transition into testable hypotheses.
- PO 3. Formulate a testable hypothesis.
- PO 4. Predict the outcome of an investigation based on prior evidence, probability, and/or modeling (not guessing or inferring).

### Concept 2: Scientific Testing (Investigating and Modeling)

Design and conduct controlled investigations.

- PO 1. Demonstrate safe and ethical procedures (e.g., use and care of technology, materials, organisms) and behavior in all science inquiry.  
**Alternate:**
1. Demonstrate safe behavior and appropriate procedures by using a comprehensive checklist delineating safe procedures, materials, and equipment for a science inquiry.
  2. Demonstrate safe behavior and appropriate procedures by using a comprehensive checklist delineating safe procedures, materials, and equipment for a science inquiry, with picture cues to assist.
  3. Given two pictures/symbols, (one of which is unrelated to the investigation) choose the illustration, object, or symbol that shows the results of an investigation
- PO 2. Identify the resources needed to conduct an investigation.
- PO 3. Design an appropriate protocol (written plan of action) for testing a hypothesis:
- Identify dependent and independent variables in a controlled investigation.
  - Determine an appropriate method for data collection (e.g., using balances, thermometers, microscopes, spectrophotometer, using qualitative changes).
  - Determine an appropriate method for recording data (e.g., notes, sketches, photographs, videos, journals (logs), charts, computers/calculators).
- PO 4. Conduct a scientific investigation that is based on a research design.
- PO 5. Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs, and computers.  
**Alternate**
1. Record observations using objects, pictures, checklists, or a computer log.
  2. Using a template, record observations using tools objects, pictures, checklists, or a computer log.
  3. Follow teacher directions to use equipment or materials related to health and safety issues.

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### Concept 3: Analysis, Conclusions, and Refinements

Evaluate experimental design, analyze data to explain results and propose further investigations.  
Design models.

PO 1. Interpret data that show a variety of possible relationships between variables, including:

- positive relationship
- negative relationship
- no relationship

**Alternate**

1. Explain the relationship between two variables.
2. Given a table or graph, explain the data.
3. Identify the variables in an investigation.

PO 2. Evaluate whether investigational data support or do not support the proposed hypothesis.

PO 3. Critique reports of scientific studies (e.g., published papers, student reports).

PO 4. Evaluate the design of an investigation to identify possible sources of procedural error, including:

- sample size
- trials
- controls
- analyses

PO 5. Design models (conceptual or physical) of the following to represent "real world" scenarios:

- carbon cycle
- water cycle
- phase change
- collisions

PO 6. Use descriptive statistics to analyze data, including:

- mean
- frequency
- range

PO 7. Propose further investigations based on the findings of a conducted investigation.

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#### Concept 4: Communication

Communicate results of investigations.

PO 1. For a specific investigation, choose an appropriate method for communicating the results.

- Alternate:**
1. Communicate results of an investigation verbally or in writing.
  2. Communicate results of an investigation using pictures, graphs, models, and/or words.
  3. Communicate observations with objects/partial objects, tactile objects, pictures, models, and/or words.

PO 2. Produce graphs that communicate data.

- Alternate:**
1. Given the appropriate graphic representation display data to communicate results of an investigation.
  2. Communicate results of an investigation using pictures, models, graphs, and/or words.
  3. Communicate the results of an investigation using objects/partial objects, and tactile symbols.

PO 3. Communicate results clearly and logically.

- Alternate**
1. Communicate one result of an investigation verbally or in writing.
  2. Communicate the results of one step in an investigation, using pictures or models.
  3. Choose the illustration or object that shows the results of an investigation.

PO 4. Support conclusions with logical scientific arguments.

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## Strand 2: History and Nature of Science

Scientific investigation grows from the contributions of many people. History and Nature of Science emphasizes the importance of the inclusion of historical perspectives and the advances that each new development brings to technology and human knowledge. This strand focuses on the human aspects of science and the role that scientists play in the development of various cultures.

### Concept 1: History of Science as a Human Endeavor

Identify individual, cultural, and technological contributions to scientific knowledge.

PO 1. Describe how human curiosity and needs have influenced science, impacting the quality of life worldwide.

PO 2. Describe how diverse people and/or cultures, past and present, have made important contributions to scientific innovations.

PO 3. Analyze how specific changes in science have affected society.

PO 4. Analyze how specific cultural and/or societal issues promote or hinder scientific advancements.

### Concept 2: Nature of Scientific Knowledge

Understand how science is a process for generating knowledge.

PO 1. Specify the requirements of a valid, scientific explanation (theory), including that it be:

- logical
- subject to peer review
- public
- respectful of rules of evidence

PO 2. Explain the process by which accepted ideas are challenged or extended by scientific innovation.

PO 3. Distinguish between pure and applied science.

PO 4. Describe how scientists continue to investigate and critically analyze aspects of theories.

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### Strand 3: Science in Personal and Social Perspectives

Science in Personal and Social Perspectives emphasizes developing the ability to design a solution to a problem, to understand the relationship between science and technology, and the ways people are involved in both. Students understand the impact of science and technology on human activity and the environment. This strand affords students the opportunity to understand their place in the world – as living creatures, consumers, decision makers, problem solvers, managers, and planners.

#### Concept 1: Changes in Environments

Describe the interactions between human populations, natural hazards, and the environment.

- PO 1. Evaluate how the processes of natural ecosystems affect, and are affected by, humans.
- PO 2. Describe the environmental effects of the following natural and/or human-caused hazards:
- flooding
  - drought
  - earthquakes
  - fires
  - pollution
  - extreme weather
- PO 3. Assess how human activities (e.g., clear cutting, water management, tree thinning) can affect the potential for hazards.
- PO 4. Evaluate the following factors that affect the quality of the environment:
- urban development
  - smoke
  - volcanic dust
- PO 5. Evaluate the effectiveness of conservation practices and preservation techniques on environmental quality and biodiversity.

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## Concept 2: Science and Technology in Society

Develop viable solutions to a need or problem.

PO 1. Analyze the costs, benefits, and risks of various ways of dealing with the following needs or problems:

- various forms of alternative energy
- storage of nuclear waste
- abandoned mines
- greenhouse gases
- hazardous wastes

PO 2. Recognize the importance of basing arguments on a thorough understanding of the core concepts and principles of science and technology.

PO 3. Support a position on a science or technology issue.

PO 4. Analyze the use of renewable and nonrenewable resources in Arizona:

- water
- land
- soil
- minerals
- air

**Alternate:**

1. Explain the impact of loss of resources in the community.
2. Describe how resources in the community are used.
3. Given two choices, indicate the picture that reflects the best usable resource (e.g., clean or murky water for drinking or bathing).

PO 5. Evaluate methods used to manage natural resources (e.g., reintroduction of wildlife, fire ecology).

## Concept 3: Human Population Characteristics

Analyze factors that affect human populations.

PO 1. Analyze social factors that limit the growth of a human population, including:

- affluence
- education
- access to health care
- cultural influences

PO 2. Describe biotic (living) and abiotic (nonliving) factors that affect human populations.

PO 3. Predict the effect of a change in a specific factor on a human population.

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## Strand 4: Life Science

Life Science expands students' biological understanding of life by focusing on the characteristics of living things, the diversity of life, and how organisms and populations change over time in terms of biological adaptation and genetics. This understanding includes the relationship of structures to their functions and life cycles, interrelationships of matter and energy in living organisms, and the interactions of living organisms with their environment.

### Concept 1: The Cell

Understand the role of the cell and cellular processes.

PO 1. Describe the role of energy in cellular growth, development, and repair.

PO 2. Compare the form and function of prokaryotic and eukaryotic cells and their cellular components.

PO 3. Explain the importance of water to cells.

PO 4. Analyze mechanisms of transport of materials (e.g., water, ions, macromolecules) into and out of cells:

- passive transport
- active transport

PO 5. Describe the purposes and processes of cellular reproduction.

### Concept 2: Molecular Basis of Heredity

Understand the molecular basis of heredity and resulting genetic diversity.

PO 1. Analyze the relationships among nucleic acids (DNA, RNA), genes, and chromosomes.

PO 2. Describe the molecular basis of heredity, in viruses and living things, including DNA replication and protein synthesis.

PO 3. Explain how genotypic variation occurs and results in phenotypic diversity.

PO 4. Describe how meiosis and fertilization maintain genetic variation.

### Concept 3: Interdependence of Organisms

Analyze the relationships among various organisms and their environment.

PO 1. Identify the relationships among organisms within populations, communities, ecosystems, and biomes.

- Alternate**
1. Describe the relationship between organisms living in the same environment.
  2. Describe various organisms' habitats.
  3. Match organisms to their habitats.

PO 2. Describe how organisms are influenced by a particular combination of biotic (living) and abiotic (nonliving) factors in an environment.

PO 3. Assess how the size and the rate of growth of a population are determined by birth rate, death rate, immigration, emigration, and carrying capacity of the environment.

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#### **Concept 4: Biological Evolution**

Understand the scientific principles and processes involved in biological evolution.

- PO 1. Identify the following components of natural selection, which can lead to speciation:
- potential for a species to increase its numbers
  - genetic variability and inheritance of offspring due to mutation and recombination of genes
  - finite supply of resources required for life
  - selection by the environment of those offspring better able to survive and produce offspring
- PO 2. Explain how genotypic and phenotypic variation can result in adaptations that influence an organism's success in an environment.
- PO 3. Describe how the continuing operation of natural selection underlies a population's ability to adapt to changes in the environment and leads to biodiversity and the origin of new species.
- PO 4. Predict how a change in an environmental factor (e.g., rainfall, habitat loss, non-native species) can affect the number and diversity of species in an ecosystem.
- PO 5. Analyze how patterns in the fossil record, nuclear chemistry, geology, molecular biology, and geographical distribution give support to the theory of organic evolution through natural selection over billions of years and the resulting present day biodiversity.
- PO 6. Analyze, using a biological classification system (i.e., cladistics, phylogeny, morphology, DNA analysis), the degree of relatedness among various species.

#### **Concept 5: Matter, Energy, and Organization in Living Systems (Including Human Systems)**

Understand the organization of living systems, and the role of energy within those systems.

- PO 1. Compare the processes of photosynthesis and cellular respiration in terms of energy flow, reactants, and products.
- PO 2. Describe the role of organic and inorganic chemicals (e.g., carbohydrates, proteins, lipids, nucleic acids, water, ATP) important to living things.
- PO 3. Diagram the following biogeochemical cycles in an ecosystem:
- water
  - carbon
  - nitrogen
- PO 4. Diagram the energy flow in an ecosystem through a food chain.
- PO 5. Describe the levels of organization of living things from cells, through tissues, organs, organ systems, organisms, populations, and communities to ecosystems.

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## Strand 5: Physical Science

Physical Science affords students the opportunity to increase their understanding of the characteristics of objects and materials they encounter daily. Students gain an understanding of the nature of matter and energy, including their forms, the changes they undergo, and their interactions. By studying objects and the forces that act upon them, students develop an understanding of the fundamental laws of motion, knowledge of the various ways energy is stored in a system, and the processes by which energy is transferred between systems and surroundings.

### Concept 1: Structure and Properties of Matter

Understand physical, chemical, and atomic properties of matter.

PO 1. Describe substances based on their physical properties.

PO 2. Describe substances based on their chemical properties.

PO 3. Predict properties of elements and compounds using trends of the periodic table (e.g., metals, non-metals, bonding – ionic/covalent).

PO 4. Separate mixtures of substances based on their physical properties.

PO 5. Describe the properties of electric charge and the conservation of electric charge.

PO 6. Describe the following features and components of the atom:

- protons
- neutrons
- electrons
- mass
- number and type of particles
- structure
- organization

PO 7. Describe the historical development of models of the atom.

PO 8. Explain the details of atomic structure (e.g., electron configuration, energy levels, isotopes).

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## Concept 2: Motions and Forces

Analyze relationships between forces and motion.

- PO 1. Determine the rate of change of a quantity (e.g., rate of erosion, rate of reaction, rate of growth, velocity).
- PO 2. Analyze the relationships among position, velocity, acceleration, and time:
- graphically
  - mathematically
- PO 3. Explain how Newton's 1<sup>st</sup> Law applies to objects at rest or moving at constant velocity.
- PO 4. Using Newton's 2<sup>nd</sup> Law of Motion, analyze the relationships among the net force acting on a body, the mass of the body, and the resulting acceleration:
- graphically
  - mathematically
- PO 5. Use Newton's 3<sup>rd</sup> Law to explain forces as interactions between bodies (e.g., a table pushing up on a vase that is pushing down on it; an athlete pushing on a basketball as the ball pushes back on her).
- PO 6. Analyze the two-dimensional motion of objects by using vectors and their components.
- PO 7. Give an example that shows the independence of the horizontal and vertical components of projectile motion.
- PO 8. Analyze the general relationships among force, acceleration, and motion for an object undergoing uniform circular motion.
- PO 9. Represent the force conditions required to maintain static equilibrium.
- PO 10. Describe the nature and magnitude of frictional forces.
- PO 11. Using the Law of Universal Gravitation, predict how the gravitational force will change when the distance between two masses changes or the mass of one of them changes.
- PO 12. Using Coulomb's Law, predict how the electrical force will change when the distance between two point charges changes or the charge of one of them changes.
- PO 13. Analyze the impulse required to produce a change in momentum.
- PO 14. Quantify interactions between objects to show that the total momentum is conserved in both collision and recoil situations.

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### Concept 3: Conservation of Energy and Increase in Disorder

Understand ways that energy is conserved, stored, and transferred.

PO 1. Describe the following ways in which energy is stored in a system:

- mechanical
- electrical
- chemical
- nuclear

PO 2. Describe various ways in which energy is transferred from one system to another (e.g., mechanical contact, thermal conduction, electromagnetic radiation.)

PO 3. Recognize that energy is conserved in a closed system.

PO 4. Calculate quantitative relationships associated with the conservation of energy.

PO 5. Analyze the relationship between energy transfer and disorder in the universe (2<sup>nd</sup> Law of Thermodynamics).

PO 6. Distinguish between heat and temperature.

PO 7. Explain how molecular motion is related to temperature and phase changes.

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#### Concept 4: Chemical Reactions

Investigate relationships between reactants and products in chemical reactions.

- PO 1. Apply the law of conservation of matter to changes in a system.
- PO 2. Identify the indicators of chemical change, including formation of a precipitate, evolution of a gas, color change, absorption or release of heat energy.
- PO 3. Represent a chemical reaction by using a balanced equation.
- PO 4. Distinguish among the types of bonds (i.e., ionic, covalent, metallic, hydrogen bonding).
- PO 5. Describe the mole concept and its relationship to Avogadro's number.
- PO 6. Solve problems involving such quantities as moles, mass, molecules, volume of a gas, and molarity using the mole concept and Avogadro's number.
- PO 7. Predict the properties (e.g., melting point, boiling point, conductivity) of substances based upon bond type.
- PO 8. Quantify the relationships between reactants and products in chemical reactions (e.g., stoichiometry, equilibrium, energy transfers).
- PO 9. Predict the products of a chemical reaction using types of reactions (e.g., synthesis, decomposition, replacement, combustion).
- PO 10. Explain the energy transfers within chemical reactions using the law of conservation of energy.
- PO 11. Predict the effect of various factors (e.g., temperature, concentration, pressure, catalyst) on the equilibrium state and on the rates of chemical reaction.
- PO 12. Compare the nature, behavior, concentration, and strengths of acids and bases.
- PO 13. Determine the transfer of electrons in oxidation/reduction reactions.

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### Concept 5: Interactions of Energy and Matter

Understand the interactions of energy and matter.

PO 1. Describe various ways in which matter and energy interact (e.g., photosynthesis, phase change).

PO 2. Describe the following characteristics of waves:

- wavelength
- frequency
- period
- amplitude

PO 3. Quantify the relationships among the frequency, wavelength, and the speed of light.

PO 4. Describe the basic assumptions of kinetic molecular theory.

PO 5. Apply kinetic molecular theory to the behavior of matter (e.g., gas laws).

PO 6. Analyze calorimetric measurements in simple systems and the energy involved in changes of state.

PO 7. Explain the relationship between the wavelength of light absorbed or released by an atom or molecule and the transfer of a discrete amount of energy.

PO 8. Describe the relationship among electric potential, current, and resistance in an ohmic system.

PO 9. Quantify the relationships among electric potential, current, and resistance in an ohmic system.

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## Strand 6: Earth and Space Science

Earth and Space Science provides the foundation for students to develop an understanding of the Earth, its history, composition, and formative processes, and an understanding of the solar system and the universe. Students study the regularities of the interrelated systems of the natural world. In doing so, they develop understandings of the basic laws, theories, and models that explain the world (NSES, 1995). By studying the Earth from both a historical and current time frame, students can make informed decisions about issues affecting the planet on which they live.

### Concept 1: Geochemical Cycles

Analyze the interactions between the Earth's structures, atmosphere, and geochemical cycles.

- PO 1. Identify ways materials are cycled within the Earth system (i.e., carbon cycle, water cycle, rock cycle).
- PO 2. Demonstrate how dynamic processes such as weathering, erosion, sedimentation, metamorphism, and orogenesis relate to redistribution of materials within the Earth system.
- PO 3. Explain how the rock cycle is related to plate tectonics.
- PO 4. Demonstrate how the hydrosphere links the biosphere, lithosphere, cryosphere, and atmosphere.
- PO 5. Describe factors that impact current and future water quantity and quality including surface, ground, and local water issues.
- PO 6. Analyze methods of reclamation and conservation of water.
- PO 7. Explain how the geochemical processes are responsible for the concentration of economically valuable minerals and ores in Arizona and worldwide.

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## **Concept 2: Energy in the Earth System (Both Internal and External)**

Understand the relationships between the Earth's land masses, oceans, and atmosphere.

PO 1. Describe the flow of energy to and from the Earth.

PO 2. Explain the mechanisms of heat transfer (convection, conduction, radiation) among the atmosphere, land masses, and oceans.

PO 3. Distinguish between weather and climate.

Internal Energy:

PO 4. Demonstrate the relationship between the Earth's internal convective heat flow and plate tectonics.

PO 5. Demonstrate the relationships among earthquakes, volcanoes, mountain ranges, mid-oceanic ridges, deep sea trenches, and tectonic plates.

PO 6. Distinguish among seismic S, P, and surface waves.

PO 7. Analyze the seismic evidence (S and P waves) used to determine the structure of the Earth.

PO 8. Describe how radioactive decay maintains the Earth's internal temperature.

External Energy:

PO 9. Explain the effect of heat transfer on climate and weather.

PO 10. Demonstrate the effect of the Earth's rotation (i.e., Coriolis effect) on the movement of water and air.

PO 11. Describe the origin, life cycle, and behavior of weather systems (i.e., air mass, front, high and low systems, pressure gradients).

PO 12. Describe the conditions that cause severe weather (e.g., hurricanes, tornadoes, thunderstorms).

PO 13. Propose appropriate safety measures that can be taken in preparation for severe weather.

PO 14. Analyze how weather is influenced by both natural and artificial Earth features (e.g., mountain ranges, bodies of water, cities, air pollution).

PO 15. List the factors that determine climate (e.g., altitude, latitude, water bodies, precipitation, prevailing winds, topography).

PO 16. Explain the causes and/or effects of climate changes over long periods of time (e.g., glaciation, desertification, solar activity, greenhouse effect).

PO 17. Investigate the effects of acid rain, smoke, volcanic dust, urban development, and greenhouse gases, on climate change over various periods of time.

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### **Concept 3: Origin and Evolution of the Earth System**

Analyze the factors used to explain the history and evolution of the Earth.

Earth Origin/System:

- PO 1. Describe the scientific theory of the origin of the solar system (solar nebular hypothesis).
- PO 2. Describe the characteristics, location, and motions of the various kinds of objects in our solar system, including the Sun, planets, satellites, comets, meteors, and asteroids.
- PO 3. Explain the phases of the Moon, eclipses (lunar and solar), and the interaction of the Sun, Moon, and Earth (tidal effect).

Earth History/Evolution:

- PO 4. Interpret a geologic time scale.
- PO 5. Distinguish between relative and absolute geologic dating techniques.
- PO 6. Investigate scientific theories of how life originated on Earth (high temperature, low oxygen, clay catalyst model).
- PO 7. Describe how life on Earth has influenced the evolution of the Earth's systems.
- PO 8. Sequence major events in the Earth's evolution (e.g., mass extinctions, glacial episodes) using relative and absolute dating data.
- PO 9. Analyze patterns in the fossil record related to the theory of organic evolution.

### **Concept 4: Origin and Evolution of the Universe**

Analyze the factors used to explain the origin and evolution of the universe.

- PO 1. Describe the Big Bang Theory as an explanation for the origin of the universe.
- PO 2. Describe the fusion process that takes place in stars.
- PO 3. Analyze the evolution of various types of stars using the Hertzsprung-Russell (HR) diagram.
- PO 4. Compare the evolution (life cycles) of stars of different masses (low and high mass).
- PO 5. Explain the formation of the light elements in stars and the heavier elements (what astronomers call "metals") in supernova explosions.
- PO 6. Explain the evolution and life cycles of galaxies.

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